

## PATENT ABSTRACTS OF JAPAN

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(54) PRODUCTION OF OPTICAL DISK

(57)Abstract:

**PROBLEM TO BE SOLVED:** To suppress the warpage of an optical disk and to shorten production time by heat-treating molded substrates before sticking to each other.

**SOLUTION:** A metallic thin film for a recording layer is formed on one face of at least one of substrates having ruggedness optionally by way of a layer of a reversibly or irreversibly changeable material. The resin substrates are disposed with faces having no ruggedness outward and the metallic thin film inward, an adhesive is supplied to one or both of the substrates and the adhesive is cured to stick the substrates to each other. Before this sticking, the substrates are subjected to prescribed heat treatment by holding in a thermostat kept at a prescribed temperature.

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CLAIMS

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## [Claim(s)]

[Claim 1]. Are obtained by making adhesives intervene and pasting two or more substrates together between them. it is a manufacturing method of an optical disc which has at least one recording layer -- (1) -- at least one substrate has predetermined unevenness on the surface of one side. A process of fabricating two or more substrates, a process of forming a metal thin film on the surface of a substrate which has (2) unevenness, And a manufacturing method characterized by heat-treating a substrate before carrying out a process (3) of pasting a substrate together, in a manufacturing method of an optical disc including a process of pasting a substrate together by laminating a substrate so that (3) metal thin film may be located inside, and supplying adhesives between substrates.

[Claim 2]The manufacturing method according to claim 1 which includes further a process of forming a layer of a substance which can be changed \*\* reversible by a predetermined light between the surface of a substrate and a metal thin film which have unevenness, between processes (1) (2).

[Claim 3]The manufacturing method according to claim 1 which includes further a process of forming a layer of a substance which can be changed irreversible by a predetermined light between the surface of a substrate and a metal thin film which have unevenness, between processes (1) (2).

[Claim 4]A method according to any one of claims 1 to 3 of enforcing by holding heat treatment in a temperature requirement of a temperature lower 10 \*\* than softening temperature of resin which uses a substrate for 60 \*\* - a substrate for 1 second - 60 minutes.

[Claim 5]The manufacturing method according to any one of claims 1 to 4 which carries out heat treatment before a process (3) after a process (2).

[Claim 6]The manufacturing method according to any one of claims 1 to 4 which carries out heat treatment before a process (2) after a process (1).

[Claim 7]The manufacturing method according to any one of claims 1 to 4 which carries out heat treatment between processes (2).

[Claim 8]The manufacturing method according to claim 7 which carries out a process (2) using plasma and heat-treats by heating a substrate by plasma.

[Claim 9]The manufacturing method according to claim 7 or 8 which heat-treats by heating a substrate holder which holds a substrate in a process (2).

[Claim 10]The manufacturing method according to any one of claims 1 to 9 which lowers temperature of a substrate until a difference with environmental temperature of the following process will be about 5 °C or less before carrying out the following process after heat treatment.

[Claim 11]The manufacturing method according to claim 10 which lowers temperature in 1 minute at least.

[Claim 12]The manufacturing method according to any one of claims 1 to 11 whose adhesives are UV cure adhesive.

[Claim 13]The manufacturing method according to any one of claims 1 to 12 whose optical disc is an optical disc for DVD.

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DETAILED DESCRIPTION

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[Detailed Description of the Invention]

[0001]

[Field of the Invention]This invention relates to the manufacturing method of the manufacturing method of an optical disc, especially a bonding type optical disc, for example, the optical disc for DVD.

[0002]

[Description of the Prior Art]The art of manufacturing the bonding type optical disc which enabled multilayer record is known by pasting together two or more substrates (usually two sheets) provided with the recording layer as an optical disc for DVD.

[0003]The manufacturing method of such a bonding type optical disc is typically shown in drawing 6. In drawing 6, one pair of substrates for disks (d1 and d2) which have predetermined unevenness in one side are resin-molded, and the metal thin film (in this case, a metal thin film functions as a recording layer) of the predetermined thickness as a reflection film is formed to the field which has unevenness of a substrate.

Then, after neglecting it automatically about 1 day and night, UV cure adhesive g is supplied and laminated between a pair of substrates in the state where the metal membrane was made to counter, by irradiating with ultraviolet rays and hardening adhesives after that, a substrate is pasted together and manufacture of optical disc D is completed.

Thus, by pasting an optical disc together and considering it as mold structure, there is an advantage that the storage capacity of an optical disc can be doubled substantially.

[0004]Such a manufacturing method of the bonding type optical disc is indicated by WO 97/No. 35702, for example. After obtaining the substrate which carries out injection molding of transparent resin like polycarbonate there, and has unevenness in one side, One pair of substrates in which metal thin films, such as gold and aluminum, were formed to the rugged surface are held in the state where a comparatively narrow gap is separated and a metal thin

film counters, The optical disc in which two or more substrates were pasted together is manufactured by breathing out adhesives, for example, UV cure adhesive, in the gap, obtaining a layered product and carrying out ultraviolet curing of the adhesives by extending and laying on top of the whole gap.

[0005]Predetermined unevenness is beforehand formed in the substrate of the optical disc manufactured in this way at the time of injection molding.

It adheres to the metal thin film in the rugged surface, and although the optical disc obtained is a read-only (what is called a ROM type) thing, the optical disc of rewritable type (what is called a RAM type) can be manufactured similarly.

In that case, the unevenness for a land and grooves is beforehand formed in one surface of a substrate. Then, after the recording layer made by the substance (for example, GeSbTe film) which can be changed reversible (for example, phase change between crystal-amorphous) is formed of sputtering process for example, on a rugged surface, it differs in that the metal thin film as a reflecting layer is formed.

[0006]Although an added-a postscript type (what is called an R form) optical disc can be manufactured similarly, In this case, after forming the recording layer irreversibly made by the substances (for example, organic-coloring-matter material, a charge of an alloy, etc. which can be decomposed by light) which can change by sputtering process reversibly [ an erasable type ] instead of the recording layer in which phase-number conversion is possible, it differs in that the metal thin film as a reflecting layer is formed. A bonding type optical disc can be manufactured by pasting together also about the optical disc (a RAM type and an R form) which can record these both sides, after forming each substrate.

[0007]In the manufacturing method of the above-mentioned optical disc, also in which mold, after forming a metal thin film on a substrate, these substrates are pasted together, but the mode of each substrate can correct many things if needed. For example, because the predetermined thickness of an optical disc is attained, when pasting together (therefore, quantity of record data is not increased), it is not necessary to provide a recording layer in one substrate. In another mode, after forming a metal thin film, a protective layer may be provided with resin on it.

[0008]Reading from the recording layer of the data using such an optical disc already recorded by predetermined unevenness or the writing of the data to a recording layer, and reading of the data, Carrying out the high velocity revolution of the optical disc, it irradiates with the laser beam of predetermined wavelength from the outside of a disk, and carries out by making a transparent substrate penetrate. Since the storage density of these data is very high, if the flatness (or display flatness, for example, a camber angle, serves as an index.) of a disk is bad, it cannot glare so that laser beams may gather in the prescribed position of a recording layer, but will become easy to produce an error in writing/reading of information. Therefore, it is

important to control generating of curvature/distortion and to obtain the optical disc which has high flatness in manufacture of an optical disc.

[0009]

[Problem(s) to be Solved by the Invention]Under the above-mentioned background, as a result of repeating various examination about the flatness of an optical disc, curvature arose in the optical disc in the process to which photo-curing of the adhesives is carried out, and it was found out that it has big influence on the flatness of the optical disc as a final product. It is guessed that this curvature will be what is produced when a disk curves in the side in which contraction of the substrate which a heat board contracts and the substrate at the time of ultraviolet curing pastes together in connection with it is large when pasting the resin-molded substrate together.

[0010]The modification by such curvature from a large thing as the case where UV irradiation is carried out in the state where substrate temperature is high. Pasting substrates together is performed, after fabricating a substrate, or after forming a metal thin film to a substrate, neglecting the substrate in the room temperature over time long enough (namely, natural neglect) and stabilizing the molecule state of resin of a substrate. The processing which neglects this substrate automatically can also be called annealing treatment, and is performed over several hours - about 24 hours as mentioned above.

[0011]However, when it is going to mass-produce an optical disc, in a manufacturing process, it is troublesome and the annealing treatment which requires such a long time is used [ inefficient ]. Considerable long time is taken [ after starting manufacture of an optical disc ] to obtain the finished product of an optical disc, and quick manufacture cannot be performed. In order to perform annealing treatment, the large place which keeps a lot of substrates temporarily is needed.

[0012]The curvature which is produced in the preservation after manufacture or an operating environment and which curves, namely, is generated temporally is one of the curvature relevant to an optical disc. Even if it is checked at the time of the completion of manufacture of an optical disc that the curvature of an optical disc is in predetermined specification within the limits by various product inspection, if use is repeated over a long period of time, a cambered amount will increase and trouble will occur an optical disc in reading/writing of data. That whose curvature by the heat contraction of the substrate mentioned above when the quantity of heat for the heat accumulation by long-term use with this big was added increases further, and idea \*\*\*\*\*.

[0013]Therefore, in manufacture of a bonding type optical disc, SUBJECT of this invention controls that modification like curvature occurs in an optical disc, and there is in making it possible to obtain the optical disc whose flatness improved. Although the thing for DVD is marketed as a bonding-type optical disc, Especially, although this invention is useful to the

optical disc for DVD so, it is not limited and can be applied to other bonding-type optical discs (for example, CD, PD, LD, etc.) if needed, so that clearly from the following explanation.

[0014]

[Means for Solving the Problem] In a case where an optical disc is manufactured by pasting a substrate together as a result of examining curvature of an optical disc manufactured by pasting together a substrate which passed through prolonged annealing treatment as mentioned above, Though curvature produced in an optical disc by heat-treating a substrate was controlled before pasting a substrate together after fabricating a substrate, it was found out that production time of an optical disc can be shortened.

[0015] First, in a manufacturing method of an optical disc, a measurement result of curvature of an optical disc thought out to heat-treat is explained. Various curvature of an optical disc (only prolonged annealing treatment was omitted and manufactured by a conventional method) manufactured using a substrate which was picked out from a making machine, without carrying out prolonged annealing treatment explained in conventional technology, and was neglected for 4 minutes was measured. As a result, it is shown in drawing 4. This is the graph which plotted variation of a camber angle after examining before doing the environmental test of a camber angle (namely, camber angle after pasting) and a disk of an optical disc obtained by lamination.

[0016] An optical disc which it faced obtaining this graph and was manufactured was a substrate for DVD made from polycarbonate, and after forming a metal thin film to what was allowed to stand at a room temperature for 4 minutes after picking out a substrate which carried out ejection formation from a metallic mold, it was pasted together using UV cure adhesive. A camber angle was measured based on a method specified to SD standard using a commercial optical camber angle measuring device. an environmental test -- 96 hours in inside of atmosphere of temperature of 80 \*\*, and 85% of humidity -- preservation -- it carried out on conditions.

[0017] This graph shows that correlation in which what has smaller variation of a camber angle has a larger camber angle after pasting exists before and after an environmental test, as a solid line shows. If it puts in another way, this means that variation of curvature by a heat history of an environmental test becomes small after that, if a substrate transforms adhesives in a process which carries out photo-curing and curvature arises. That is, heat contraction is carried out at the time of hardening, I hear that further deformation of the after that of a substrate which changed is small compared with further deformation of a substrate which has not yet carried out heat contraction, and there is. If another expression is carried out, deformation as the whole peculiar to a substrate would be decided, and a substrate of a disk with large curvature after pasting, Actualize, when a great portion of curvature is already lamination, and it has only small potential curvature (this small potential curvature actualizes

by an environmental test), On the contrary, it can be said that a substrate of a disk with small curvature after pasting has potential large curvature (this potential large curvature actualizes by an environmental test).

[0018]If are based on such knowledge and modification of a substrate will actualize modification beforehand, it will be presumed that modification produced later becomes small. Namely, if the great portion of potential curvature peculiar to a substrate is actualized before pasting a substrate together, Though curvature which it has potentially in a substrate decreased and an optical disc produced curvature the time of photo-curing, and after completion of an optical disc as a result, after pasting a substrate together, when it compared with the conventional optical disc, it found out that the curvature will become small. Artificers found out that it was also possible by heat-treating a substrate to actualize the great portion of potential curvature peculiar to this substrate before pasting a substrate together.

[0019]. Therefore, this invention is obtained by making adhesives intervene and pasting two or more substrates together between them. it is a manufacturing method of an optical disc which has at least one recording layer -- (1) -- at least one substrate has predetermined unevenness on the surface of one side. A process of fabricating two or more substrates, a process of forming a metal thin film on the surface of a substrate which has (2) unevenness, And in a manufacturing method of an optical disc including a process of pasting a substrate together by laminating a substrate so that (3) metal thin film may be located inside, and supplying adhesives between substrates, Before carrying out a process (3) of pasting a substrate together, a manufacturing method heat-treating a substrate is provided.

[0020]In this invention, except for heat-treating a substrate, process (1) - (3), It may be the process currently obligatorily carried out in a manufacturing method of a lamination optical disc, and may carry out obligatorily in a manufacturing method of a lamination optical disc also about the material etc. which are used in an operating condition of such a process, and a process.

[0021]In this invention, although two or more substrates mean pasting two or more substrates together and are usually two substrates, also when manufacturing an optical disc by pasting three or more substrates together in being required, a method of this invention can be applied. At least one substrate has predetermined unevenness (unevenness for unevenness corresponding to predetermined record or a land, and grooves) on surface of one of the two among these substrates, and the unevenness is covered with a metal thin film which reflects light. Therefore, when it is not necessary to have and has unevenness even if other substrates to paste together have predetermined unevenness or, a metal thin film is formed also on the unevenness.

[0022]In being an optical disc which is not read-only, i.e., an optical disc which can write in information later, a method of this invention has further reversibly a convertible recording layer

or the process of providing irreversibly a recording layer which can change, by light of predetermined wavelength on unevenness before a process (2).

[0023]Heat treatment as used in a method of this invention means processing which a fabricated substrate makes reveal beforehand promptly under heating of a peculiar target and curvature which it has potentially. Temperature specifically lower about 10 ° than softening temperature of resin used for 60 ° - a substrate (for example, in the case of polycarbonate) 110 ° of this inventions [ 70 ° - 100 ° of ] can be more preferably heat-treated for a substrate at 70 ° - 90 °, for example, 80 °, by predetermined time and processing usually held preferably for 1 minute - 30 minutes for 1 second - 60 minutes.

[0024]Unless it has a substantial adverse effect on a substrate, atmosphere of heat treatment may be carried out in which atmosphere, for example, is carried out in inert gas like nitrogen among the air. It may be compulsorily cooled with a gas for cooling (for example, air) even if after heat treatment neglects a substrate in room temperature atmosphere and cools naturally for the following lamination process, or on the assumption that it is cooled uniformly substantially.

[0025]Heat treatment may be carried out after a process (1) of fabricating a substrate at which stage in front of a process (3) of pasting a substrate together, for example, may be carried out after a process (1) after a process (2), between processes (2), or in its part. Generally, it is preferred to carry out after a process (2).

[0026]

[Embodiment of the Invention]Although the method of this invention is hereafter explained still in detail with reference to the desirable feature of this invention, as mentioned above, except for heat treatment, it may carry out like conventionality. According to the specification of the optical disc to manufacture, the substrate used in the method of this invention is manufactured, where detailed predetermined unevenness is formed in one side of a substrate of injection molding from transparent resin (for example, polycarbonate). The predetermined unevenness currently formed in the substrate face may be unevenness corresponding to the data which should be read in a read-only optical disc case, and, in the case of the optical disc which can be written in, may be unevenness corresponding to the land and groove which write in data.

[0027]Such a substrate can be manufactured with molding equipment and a forming process same with using it for manufacture of the usual substrate for optical discs, and, generally, an injection-molding device and a method can be used for it. When manufacturing a substrate, the cavity which specifies the opening corresponding to the outside of a substrate by the meantime by the molding die of the couple arranged at the upper and lower sides or right and left is formed. Since it is necessary to provide unevenness detailed as mentioned above in one side of a substrate, the unevenness corresponding to it is formed in a cavity.

[0028]In injection molding, heating and the resin material by which melting was carried out are

supplied with high voltage in the cavity formed by the forming mold. Operating conditions, such as ejection temperature and injection pressure, may be the same as what is adopted as manufacture of the substrate of the usual optical disc. In order to maintain the good flow of the melting resin supplied in the metallic mold, a metallic mold is usually heated by prescribed temperature.

[0029]For example, when pasting two substrates together and manufacturing an optical disc, a making machine is manufactured by \*\*\*\*\* , each disk is manufactured by a separate series 2 system, and one pair of substrates are obtained in many cases. Thus, the warping characteristics of one pair of substrates manufactured with the making machine of a different series were made to match, it is difficult to make curvature into the minimum, and, as a result, heat modification slack curvature had arisen in the optical disc according to a difference of the amount of heat contraction of both substrates at the time of the lamination of a substrate. In the method of this invention, since the substrate is beforehand heat-treated for the substrate and potential deformation is becoming less, when pasting such a substrate together, the modification produced according to the heat and peripheral environment at the time of photo-curing decreases substantially.

[0030]A recording layer is formed on the substrate face which has unevenness. In the case of a read-only optical disc, the metal thin film formed on the rugged surface functions as a recording layer, and in the case of the optical disc which can be written in, It functions as a recording layer together with the metal thin film which was formed on the rugged surface and in which the layer of the substance which can be changed reversible or irreversible was formed on it of the light of predetermined wavelength. The recording layer as used in this invention means the layer which has already recorded data, or a recordable layer. On this recording layer, a ZnS film, a SiO<sub>2</sub> film, etc. may be formed as a protective film by carrying out sputtering if needed.

[0031]Although the metal thin film for a recording layer is formed on the layer of a substance which was provided on the single-sided surface which has unevenness of a substrate, or it and which can be changed reversible or irreversible, this can carry it out like the case of manufacture of the usual optical disc. Gold, aluminum, and the material currently used for the other usual optical discs can be used for the material of a metal thin film. As a method for forming thin film, vacuum deposition, CVD, PVD, etc. are employable. When heating a substrate on the occasion of thin film forming, an electric heater, a lamp, etc. can be used as a heating method.

[0032]Since a recording layer is constituted as mentioned above in the case of the optical disc which can be written in, the layer of the material which is combined with a metal thin film and which can be changed reversible or irreversible is formed on the irregular surface of a substrate. This layer as well as the case of manufacture of the optical disc in which the usual

writing is possible can be formed, for example by vacuum evaporation, a spin coat, sputtering, etc.

[0033]Finally, the substrate (by a case, it has further the layer and/or protective layer of the material which can be changed reversible or irreversible) which has a metal thin film as mentioned above is pasted together. A substrate is arranged so that the surface where unevenness of a resin substrate does not exist may be located outside on the occasion of this lamination and a metal thin film may be located inside. For example, when the substrate to paste together has a metal thin film, respectively, it arranges so that a metal thin film may counter. Although the shape of a substrate is generally thin discoid (a circular hole may exist in a center section), it may be shape other than a disk for some utilization objects of the substrate pasted together. The shape of a substrate may be processed into another shape after pasting together.

[0034]This lamination as well as the case where the usual optical disc is manufactured can be carried out using adhesives. It is preferred to use various photo-curing type adhesives, especially transparent ultraviolet curing type adhesives, for example, acrylic UV curing resin, as adhesives according to the construction material of the substrate of a field to paste together and a utilization object.

[0035]A usual adhesive application or paint means is used for this lamination, it supplies adhesives, makes substrates a layered product in piles, irradiates this if needed, and makes one of the two or the both sides of one pair of substrates harden adhesives. As a desirable method of pasting together, the following methods are especially employable.

[0036]Adhesives are annularly supplied in a gap by rotating one pair of substrates around the center, making one substrate counter, where a comparatively narrow interval is separated, holding, inserting the regurgitation nozzle of adhesives in the gap, and breathing out adhesives from a regurgitation nozzle. Then, the gap of a substrate is narrowed, and by rotating both substrates, a substrate can open adhesives radially, the gap of a substrate can be filled up with the layer of thin adhesives, a layered product is obtained, and adhesives are hardened by irradiating with light after that. This method of pasting together is indicated by WO 97/No. 35702 quoted previously, and this disclosure constitutes some of these Descriptions by this citation.

[0037]In order to stiffen an adhesives layer by light, especially ultraviolet rays, Usually, by locating the lamp which emits a predetermined light in a pair of upper part of the substrate layered product arranged by the horizontal state on a flat mounting base, making it irradiate with light from this lamp, and passing a transparent substrate and a semipermeability metal thin film, an adhesives layer is made to reach and it hardens. In addition, or by an exception method, when the light transmittance state of a metal thin film is small, it may harden by what (that is, it glares from a vertical direction to the thickness direction of a layered product) is

irradiated with light from the side of a layered product.

[0038]As mentioned above, heat treatment which is the main feature of the method of this invention can be carried out by holding a substrate within the thermostat maintained by the temperature of 60 ° - 110 °, for example, before pasting a substrate together. In another mode, it may heat-treat at the time of formation of a metal thin film. For example, it can carry out by facing using CVD or PVD for formation of a metal thin film, and heating a substrate with the heat of the plasma to be used. As long as the substrate formed by resin molding does not change a substrate substantially in the handling of the substrate after shaping even if cooled by the room temperature or before heat-treating, it may be a higher temperature. Of course, since what is necessary is just to carry out heat treatment before the lamination of a substrate, it is also possible to carry out after formation of a metal thin film.

[0039]After heat treatment, as for a substrate, before carrying out the following process, it is preferred to lower the temperature until a difference with the environmental temperature (it pastes together in pasting together to the next and carrying out a process, and it is the temperature of the formation atmosphere when usually forming a metal thin film in a room temperature or the next, the temperature of the atmosphere of a process and) will be about 5 ° or less. Usually, for this temperature fall put close to the environmental temperature of a lamination process, it is preferred to spend at least preferably for 3 minutes at least for 1 minute.

[0040]The temperature fall of this substrate can also be compulsorily carried out what is necessary being just to neglect the substrate in environment, and hitting a substrate in cold blast, or by contacting a low-temperature object and a substrate. However, it is necessary to avoid cooling rapid like it brings about generating of heat stress or heat distortion, or uneven cooling. The temperature fall time after this heat treatment can be adjusted by changing the transfer rate of a substrate. For example, temperature fall time can be changed by changing the speed or length of a conveyor which transports a substrate.

[0041]One mode of the method of this invention is typically shown in drawing 1. In the forming cycle (1) of a substrate, the doughnut shape (disk which has circular opening part in center) boards d1 and d2 are manufactured using an injection-molding device. Predetermined unevenness is formed in the surface of one of the two of each substrate. Unevenness does not need to be formed in one substrate in another mode. Next, in stage film formation (2), a metal thin film is formed on the irregular surface of each substrate using a sputtering system. For example, a golden thin film is formed in the substrate d1, and the thin film of aluminum is formed in the substrate d2. When a substrate does not have unevenness, it is not necessary to form a metal thin film.

[0042]Then, heat treatment is pasted together and it carries out before a process (3). In drawing 1, after forming a thin film, it heat-treats, but in another mode, it may heat-treat in

stage film formation (2). In stage film formation (2), it can heat-treat using a sputtering system as typically shown, for example in drawing 2 with a sectional view. By making a substrate (12) and a target (14) counter and changing the distance (T/S distance) between a target (14) and a substrate (12) within sputtering chambers (10), in this device, The grade of influence in the substrate of the thermal energy of plasma can be changed, and, as a result, the rise in heat of a substrate can be controlled like predetermined.

[0043]The influence of the temperature on the substrate of the T/S distance in the case of forming the thin film of aluminum is illustrated in the graph of drawing 3. For example, if T/S distance shall be 40 mm and 1500V intensity impression is carried out by DC power supply (16), the temperature of a substrate (12) will rise at about 70 \*\*, and it will be heated by still higher temperature if it shortens more. Therefore, in the process of forming a metal thin film, it becomes possible to heat-treat this invention. In another mode, it is also possible to include a heating method, for example, an electric heater, in the substrate holder (11) of a sputtering system, or to heat a substrate like predetermined with a lamp.

[0044]Adhesives are annularly supplied by rotating the substrates d1 and d2, holding one pair of substrates d1 and d2, inserting the tip nozzle of the adhesives feeder G in a gap, and breathing out the adhesives g so that a metal thin film may separate a gap and may counter after above-mentioned heat treatment. If the adhesives which narrow the gap of the substrate and are breathed out at this time are arranged where an up-and-down substrate is contacted, the application unevenness of adhesives can be substantially prevented from air bubbles permeating between substrates by the following laminating process, or arising.

[0045]In a laminating process, the layered product which the adhesives layer by which it is placed between gaps was thinly extended on the whole between substrates, and substrates stuck is obtained by narrowing these gaps further, rotating the substrates d1 and d2. Finally, it irradiates with ultraviolet ray lamp L to ultraviolet rays from one side of a layered product, adhesives are stiffened, lamination is completed, and optical disc D of this invention is obtained.

[0046]

[Effect of the Invention]In the method of this invention, since a short time is comparatively heat-treated instead of prolonged annealing treatment before the lamination of a substrate, though the curvature of the substrate produced when making adhesives heat-harden is reduced substantially, the time which the manufacturing method of an optical disc takes can be shortened substantially. As a result, the necessity which was required for annealing treatment of keeping a lot of substrates temporarily is lost (therefore). The integrated production line of a bonding type optical disc good as a small number of substrate is stocked temporarily as typically shown in drawing 5 can be realized, and productivity improves substantially. This factory line has a making machine (20) of a substrate, a thermal treatment equipment (30), a

metal system for thin film deposition (40), and a substrate laminating device (50).

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TECHNICAL FIELD

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[Field of the Invention]This invention relates to the manufacturing method of the manufacturing method of an optical disc, especially a bonding type optical disc, for example, the optical disc for DVD.

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PRIOR ART

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[Description of the Prior Art]The art of manufacturing the bonding type optical disc which enabled multilayer record is known by pasting together two or more substrates (usually two sheets) provided with the recording layer as an optical disc for DVD.

[0003]The manufacturing method of such a bonding type optical disc is typically shown in drawing 6. In drawing 6, one pair of substrates for disks (d1 and d2) which have predetermined unevenness in one side are resin-molded, and the metal thin film (in this case, a metal thin film functions as a recording layer) of the predetermined thickness as a reflection film is formed to the field which has unevenness of a substrate.

Then, after neglecting it automatically about 1 day and night, UV cure adhesive g is supplied and laminated between a pair of substrates in the state where the metal membrane was made to counter, by irradiating with ultraviolet rays and hardening adhesives after that, a substrate is pasted together and manufacture of optical disc D is completed.

Thus, by pasting an optical disc together and considering it as mold structure, there is an advantage that the storage capacity of an optical disc can be doubled substantially.

[0004]Such a manufacturing method of the bonding type optical disc is indicated by WO 97/No. 35702, for example. After obtaining the substrate which carries out injection molding of transparent resin like polycarbonate there, and has unevenness in one side, One pair of substrates in which metal thin films, such as gold and aluminum, were formed to the rugged surface are held in the state where a comparatively narrow gap is separated and a metal thin film counters, The optical disc in which two or more substrates were pasted together is manufactured by breathing out adhesives, for example, UV cure adhesive, in the gap, obtaining a layered product and carrying out ultraviolet curing of the adhesives by extending and laying on top of the whole gap.

[0005]Predetermined unevenness is beforehand formed in the substrate of the optical disc manufactured in this way at the time of injection molding.

It adheres to the metal thin film in the rugged surface, and although the optical disc obtained is a read-only (what is called a ROM type) thing, the optical disc of rewritable type (what is called a RAM type) can be manufactured similarly.

In that case, the unevenness for a land and grooves is beforehand formed in one surface of a substrate, Then, after the recording layer made by the substance (for example, GeSbTe film) which can be changed reversible (for example, phase change between crystal-amorphous) is formed of sputtering process for example, on a rugged surface, it differs in that the metal thin film as a reflecting layer is formed.

[0006]Although an added-a postscript type (what is called an R form) optical disc can be manufactured similarly, In this case, after forming the recording layer irreversibly made by the substances (for example, organic-coloring-matter material, a charge of an alloy, etc. which can be decomposed by light) which can change by sputtering process reversibly [ an erasable type ] instead of the recording layer in which phase-number conversion is possible, it differs in that the metal thin film as a reflecting layer is formed. A bonding type optical disc can be manufactured by pasting together also about the optical disc (a RAM type and an R form) which can record these both sides, after forming each substrate.

[0007]In the manufacturing method of the above-mentioned optical disc, also in which mold, after forming a metal thin film on a substrate, these substrates are pasted together, but the mode of each substrate can correct many things if needed. For example, because the predetermined thickness of an optical disc is attained, when pasting together (therefore, quantity of record data is not increased), it is not necessary to provide a recording layer in one substrate. In another mode, after forming a metal thin film, a protective layer may be provided with resin on it.

[0008]Reading from the recording layer of the data using such an optical disc already recorded by predetermined unevenness or the writing of the data to a recording layer, and reading of the data, Carrying out the high velocity revolution of the optical disc, it irradiates with the laser beam of predetermined wavelength from the outside of a disk, and carries out by making a transparent substrate penetrate. Since the storage density of these data is very high, if the flatness (or display flatness, for example, a camber angle, serves as an index.) of a disk is bad, it cannot glare so that laser beams may gather in the prescribed position of a recording layer, but will become easy to produce an error in writing/reading of information. Therefore, it is important to control generating of curvature/distortion and to obtain the optical disc which has high flatness in manufacture of an optical disc.

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## EFFECT OF THE INVENTION

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[Effect of the Invention]In the method of this invention, since a short time is comparatively heat-treated instead of prolonged annealing treatment before the lamination of a substrate, though the curvature of the substrate produced when making adhesives heat-harden is reduced substantially, the time which the manufacturing method of an optical disc takes can be shortened substantially. As a result, the necessity which was required for annealing treatment of keeping a lot of substrates temporarily is lost (therefore). The integrated production line of a bonding type optical disc good as a small number of substrate is stocked temporarily as typically shown in drawing 5 can be realized, and productivity improves substantially. This factory line has a making machine (20) of a substrate, a thermal treatment equipment (30), a metal system for thin film deposition (40), and a substrate laminating device (50).

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## TECHNICAL PROBLEM

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[Problem(s) to be Solved by the Invention]Under the above-mentioned background, as a result of repeating various examination about the flatness of an optical disc, curvature arose in the optical disc in the process to which photo-curing of the adhesives is carried out, and it was found out that it has big influence on the flatness of the optical disc as a final product. It is guessed that this curvature will be what is produced when a disk curves in the side in which contraction of the substrate which a heat board contracts and the substrate at the time of ultraviolet curing pastes together in connection with it is large when pasting the resin-molded substrate together.

[0010]The modification by such curvature from a large thing as the case where UV irradiation is carried out in the state where substrate temperature is high. Pasting substrates together is performed, after fabricating a substrate, or after forming a metal thin film to a substrate, neglecting the substrate in the room temperature over time long enough (namely, natural neglect) and stabilizing the molecule state of resin of a substrate. The processing which neglects this substrate automatically can also be called annealing treatment, and is performed over several hours - about 24 hours as mentioned above.

[0011]However, when it is going to mass-produce an optical disc, in a manufacturing process, it is troublesome and the annealing treatment which requires such a long time is used [ inefficient ]. Considerable long time is taken [ after starting manufacture of an optical disc ] to obtain the finished product of an optical disc, and quick manufacture cannot be performed. In order to perform annealing treatment, the large place which keeps a lot of substrates temporarily is needed.

[0012]The curvature which is produced in the preservation after manufacture or an operating environment and which curves, namely, is generated temporally is one of the curvature relevant to an optical disc. Even if it is checked at the time of the completion of manufacture of an optical disc that the curvature of an optical disc is in predetermined specification within the

limits by various product inspection, if use is repeated over a long period of time, a cambered amount will increase and trouble will occur an optical disc in reading/writing of data. That whose curvature by the heat contraction of the substrate mentioned above when the quantity of heat for the heat accumulation by long-term use with this big was added increases further, and idea \*\*\*\*\*.

[0013]Therefore, in manufacture of a bonding type optical disc, SUBJECT of this invention controls that modification like curvature occurs in an optical disc, and there is in making it possible to obtain the optical disc whose flatness improved. Although the thing for DVD is marketed as a bonding-type optical disc, Especially, although this invention is useful to the optical disc for DVD so, it is not limited and can be applied to other bonding-type optical discs (for example, CD, PD, LD, etc.) if needed, so that clearly from the following explanation.

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MEANS

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[Means for Solving the Problem]In a case where an optical disc is manufactured by pasting a substrate together as a result of examining curvature of an optical disc manufactured by pasting together a substrate which passed through prolonged annealing treatment as mentioned above, Though curvature produced in an optical disc by heat-treating a substrate was controlled before pasting a substrate together after fabricating a substrate, it was found out that production time of an optical disc can be shortened.

[0015]First, in a manufacturing method of an optical disc, a measurement result of curvature of an optical disc thought out to heat-treat is explained. Various curvature of an optical disc (only prolonged annealing treatment was omitted and manufactured by a conventional method) manufactured using a substrate which was picked out from a making machine, without carrying out prolonged annealing treatment explained in conventional technology, and was neglected for 4 minutes was measured. As a result, it is shown in drawing 4. This is the graph which plotted variation of a camber angle after examining before doing the environmental test of a camber angle (namely, camber angle after pasting) and a disk of an optical disc obtained by lamination.

[0016]An optical disc which it faced obtaining this graph and was manufactured was a substrate for DVD made from polycarbonate, and after forming a metal thin film to what was allowed to stand at a room temperature for 4 minutes after picking out a substrate which carried out ejection formation from a metallic mold, it was pasted together using UV cure adhesive. A camber angle was measured based on a method specified to SD standard using a commercial optical camber angle measuring device. an environmental test -- 96 hours in inside of atmosphere of temperature of 80 \*\*, and 85% of humidity -- preservation -- it carried out on conditions.

[0017]This graph shows that correlation in which what has smaller variation of a camber angle has a larger camber angle after pasting exists before and after an environmental test, as a

solid line shows. If it puts in another way, this means that variation of curvature by a heat history of an environmental test becomes small after that, if a substrate transforms adhesives in a process which carries out photo-curing and curvature arises. That is, heat contraction is carried out at the time of hardening, I hear that further deformation of the after that of a substrate which changed is small compared with further deformation of a substrate which has not yet carried out heat contraction, and there is. If another expression is carried out, deformation as the whole peculiar to a substrate would be decided, and a substrate of a disk with large curvature after pasting, Actualize, when a great portion of curvature is already lamination, and it has only small potential curvature (this small potential curvature actualizes by an environmental test), On the contrary, it can be said that a substrate of a disk with small curvature after pasting has potential large curvature (this potential large curvature actualizes by an environmental test).

[0018]If are based on such knowledge and modification of a substrate will actualize modification beforehand, it will be presumed that modification produced later becomes small. Namely, if the great portion of potential curvature peculiar to a substrate is actualized before pasting a substrate together, Though curvature which it has potentially in a substrate decreased and an optical disc produced curvature the time of photo-curing, and after completion of an optical disc as a result, after pasting a substrate together, when it compared with the conventional optical disc, it found out that the curvature will become small. Artificers found out that it was also possible by heat-treating a substrate to actualize the great portion of potential curvature peculiar to this substrate before pasting a substrate together.

[0019]. Therefore, this invention is obtained by making adhesives intervene and pasting two or more substrates together between them. it is a manufacturing method of an optical disc which has at least one recording layer -- (1) -- at least one substrate has predetermined unevenness on the surface of one side. A process of fabricating two or more substrates, a process of forming a metal thin film on the surface of a substrate which has (2) unevenness, And in a manufacturing method of an optical disc including a process of pasting a substrate together by laminating a substrate so that (3) metal thin film may be located inside, and supplying adhesives between substrates, Before carrying out a process (3) of pasting a substrate together, a manufacturing method heat-treating a substrate is provided.

[0020]In this invention, except for heat-treating a substrate, process (1) - (3), It may be the process currently obligatorily carried out in a manufacturing method of a lamination optical disc, and may carry out obligatorily in a manufacturing method of a lamination optical disc also about the material etc. which are used in an operating condition of such a process, and a process.

[0021]In this invention, although two or more substrates mean pasting two or more substrates together and are usually two substrates, also when manufacturing an optical disc by pasting

three or more substrates together in being required, a method of this invention can be applied. At least one substrate has predetermined unevenness (unevenness for unevenness corresponding to predetermined record or a land, and grooves) on surface of one of the two among these substrates, and the unevenness is covered with a metal thin film which reflects light. Therefore, when it is not necessary to have and has unevenness even if other substrates to paste together have predetermined unevenness or, a metal thin film is formed also on the unevenness.

[0022]In being an optical disc which is not read-only, i.e., an optical disc which can write in information later, a method of this invention has further reversibly a convertible recording layer or the process of providing irreversibly a recording layer which can change, by light of predetermined wavelength on unevenness before a process (2).

[0023]Heat treatment as used in a method of this invention means processing which a fabricated substrate makes reveal beforehand promptly under heating of a peculiar target and curvature which it has potentially. Temperature specifically lower about 10 °C than softening temperature of resin used for 60 °C - a substrate (for example, in the case of polycarbonate) 110 °C of this inventions [ 70 °C - 100 °C of ] can be more preferably heat-treated for a substrate at 70 °C - 90 °C, for example, 80 °C, by predetermined time and processing usually held preferably for 1 minute - 30 minutes for 1 second - 60 minutes.

[0024]Unless it has a substantial adverse effect on a substrate, atmosphere of heat treatment may be carried out in which atmosphere, for example, is carried out in inert gas like nitrogen among the air. It may be compulsorily cooled with a gas for cooling (for example, air) even if after heat treatment neglects a substrate in room temperature atmosphere and cools naturally for the following lamination process, or on the assumption that it is cooled uniformly substantially.

[0025]Heat treatment may be carried out after a process (1) of fabricating a substrate at which stage in front of a process (3) of pasting a substrate together, for example, may be carried out after a process (1) after a process (2), between processes (2), or in its part. Generally, it is preferred to carry out after a process (2).

[0026]

[Embodiment of the Invention]Although the method of this invention is hereafter explained still in detail with reference to the desirable feature of this invention, as mentioned above, except for heat treatment, it may carry out like conventionality. According to the specification of the optical disc to manufacture, the substrate used in the method of this invention is manufactured, where detailed predetermined unevenness is formed in one side of a substrate of injection molding from transparent resin (for example, polycarbonate). The predetermined unevenness currently formed in the substrate face may be unevenness corresponding to the data which should be read in a read-only optical disc case, and, in the case of the optical disc which can

be written in, may be unevenness corresponding to the land and groove which write in data. [0027]Such a substrate can be manufactured with molding equipment and a forming process same with using it for manufacture of the usual substrate for optical discs, and, generally, an injection-molding device and a method can be used for it. When manufacturing a substrate, the cavity which specifies the opening corresponding to the outside of a substrate by the meantime by the molding die of the couple arranged at the upper and lower sides or right and left is formed. Since it is necessary to provide unevenness detailed as mentioned above in one side of a substrate, the unevenness corresponding to it is formed in a cavity.

[0028]In injection molding, heating and the resin material by which melting was carried out are supplied with high voltage in the cavity formed by the forming mold. Operating conditions, such as ejection temperature and injection pressure, may be the same as what is adopted as manufacture of the substrate of the usual optical disc. In order to maintain the good flow of the melting resin supplied in the metallic mold, a metallic mold is usually heated by prescribed temperature.

[0029]For example, when pasting two substrates together and manufacturing an optical disc, a making machine is manufactured by \*\*\*\*\*, each disk is manufactured by a separate series 2 system, and one pair of substrates are obtained in many cases. Thus, the warping characteristics of one pair of substrates manufactured with the making machine of a different series were made to match, it is difficult to make curvature into the minimum, and, as a result, heat modification slack curvature had arisen in the optical disc according to a difference of the amount of heat contraction of both substrates at the time of the lamination of a substrate. In the method of this invention, since the substrate is beforehand heat-treated for the substrate and potential deformation is becoming less, when pasting such a substrate together, the modification produced according to the heat and peripheral environment at the time of photocuring decreases substantially.

[0030]A recording layer is formed on the substrate face which has unevenness. In the case of a read-only optical disc, the metal thin film formed on the rugged surface functions as a recording layer, and in the case of the optical disc which can be written in, It functions as a recording layer together with the metal thin film which was formed on the rugged surface and in which the layer of the substance which can be changed reversible or irreversible was formed on it of the light of predetermined wavelength. The recording layer as used in this invention means the layer which has already recorded data, or a recordable layer. On this recording layer, a ZnS film, a SiO<sub>2</sub> film, etc. may be formed as a protective film by carrying out sputtering if needed.

[0031]Although the metal thin film for a recording layer is formed on the layer of a substance which was provided on the single-sided surface which has unevenness of a substrate, or it and which can be changed reversible or irreversible, this can carry it out like the case of

manufacture of the usual optical disc. Gold, aluminum, and the material currently used for the other usual optical discs can be used for the material of a metal thin film. As a method for forming thin film, vacuum deposition, CVD, PVD, etc. are employable. When heating a substrate on the occasion of thin film forming, an electric heater, a lamp, etc. can be used as a heating method.

[0032] Since a recording layer is constituted as mentioned above in the case of the optical disc which can be written in, the layer of the material which is combined with a metal thin film and which can be changed reversible or irreversible is formed on the irregular surface of a substrate. This layer as well as the case of manufacture of the optical disc in which the usual writing is possible can be formed, for example by vacuum evaporation, a spin coat, sputtering, etc.

[0033] Finally, the substrate (by a case, it has further the layer and/or protective layer of the material which can be changed reversible or irreversible) which has a metal thin film as mentioned above is pasted together. A substrate is arranged so that the surface where unevenness of a resin substrate does not exist may be located outside on the occasion of this lamination and a metal thin film may be located inside. For example, when the substrate to paste together has a metal thin film, respectively, it arranges so that a metal thin film may counter. Although the shape of a substrate is generally thin discoid (a circular hole may exist in a center section), it may be shape other than a disk for some utilization objects of the substrate pasted together. The shape of a substrate may be processed into another shape after pasting together.

[0034] This lamination as well as the case where the usual optical disc is manufactured can be carried out using adhesives. It is preferred to use various photo-curing type adhesives, especially transparent ultraviolet curing type adhesives, for example, acrylic UV curing resin, as adhesives according to the construction material of the substrate of a field to paste together and a utilization object.

[0035] A usual adhesive application or paint means is used for this lamination, it supplies adhesives, makes substrates a layered product in piles, irradiates this if needed, and makes one of the two or the both sides of one pair of substrates harden adhesives. As a desirable method of pasting together, the following methods are especially employable.

[0036] Adhesives are annularly supplied in a gap by rotating one pair of substrates around the center, making one substrate counter, where a comparatively narrow interval is separated, holding, inserting the regurgitation nozzle of adhesives in the gap, and breathing out adhesives from a regurgitation nozzle. Then, the gap of a substrate is narrowed, and by rotating both substrates, a substrate can open adhesives radially, the gap of a substrate can be filled up with the layer of thin adhesives, a layered product is obtained, and adhesives are hardened by irradiating with light after that. This method of pasting together is indicated by WO 97/No.

35702 quoted previously, and this disclosure constitutes some of these Descriptions by this citation.

[0037]In order to stiffen an adhesives layer by light, especially ultraviolet rays, Usually, by locating the lamp which emits a predetermined light in a pair of upper part of the substrate layered product arranged by the horizontal state on a flat mounting base, making it irradiate with light from this lamp, and passing a transparent substrate and a semipermeability metal thin film, an adhesives layer is made to reach and it hardens. In addition, or by an exception method, when the light transmittance state of a metal thin film is small, it may harden by what (that is, it glares from a vertical direction to the thickness direction of a layered product) is irradiated with light from the side of a layered product.

[0038]As mentioned above, heat treatment which is the main feature of the method of this invention can be carried out by holding a substrate within the thermostat maintained by the temperature of 60 \*\* - 110 \*\*, for example, before pasting a substrate together. In another mode, it may heat-treat at the time of formation of a metal thin film. For example, it can carry out by facing using CVD or PVD for formation of a metal thin film, and heating a substrate with the heat of the plasma to be used. As long as the substrate formed by resin molding does not change a substrate substantially in the handling of the substrate after shaping even if cooled by the room temperature or before heat-treating, it may be a higher temperature. Of course, since what is necessary is just to carry out heat treatment before the lamination of a substrate, it is also possible to carry out after formation of a metal thin film.

[0039]After heat treatment, as for a substrate, before carrying out the following process, it is preferred to lower the temperature until a difference with the environmental temperature (it pastes together in pasting together to the next and carrying out a process, and it is the temperature of the formation atmosphere when usually forming a metal thin film in a room temperature or the next, the temperature of the atmosphere of a process and) will be about 5 \*\* or less. Usually, for this temperature fall put close to the environmental temperature of a lamination process, it is preferred to spend at least preferably for 3 minutes at least for 1 minute.

[0040]The temperature fall of this substrate can also be compulsorily carried out what is necessary being just to neglect the substrate in environment, and hitting a substrate in cold blast, or by contacting a low-temperature object and a substrate. However, it is necessary to avoid cooling rapid like it brings about generating of heat stress or heat distortion, or uneven cooling. The temperature fall time after this heat treatment can be adjusted by changing the transfer rate of a substrate. For example, temperature fall time can be changed by changing the speed or length of a conveyor which transports a substrate.

[0041]One mode of the method of this invention is typically shown in drawing 1. In the forming cycle (1) of a substrate, the doughnut shape (disk which has circular opening part in center)

boards d1 and d2 are manufactured using an injection-molding device. Predetermined unevenness is formed in the surface of one of the two of each substrate. Unevenness does not need to be formed in one substrate in another mode. Next, in stage film formation (2), a metal thin film is formed on the irregular surface of each substrate using a sputtering system. For example, a golden thin film is formed in the substrate d1, and the thin film of aluminum is formed in the substrate d2. When a substrate does not have unevenness, it is not necessary to form a metal thin film.

[0042] Then, heat treatment is pasted together and it carries out before a process (3). In drawing 1, after forming a thin film, it heat-treats, but in another mode, it may heat-treat in stage film formation (2). In stage film formation (2), it can heat-treat using a sputtering system as typically shown, for example in drawing 2 with a sectional view. By making a substrate (12) and a target (14) counter and changing the distance (T/S distance) between a target (14) and a substrate (12) within sputtering chambers (10), in this device, The grade of influence in the substrate of the thermal energy of plasma can be changed, and, as a result, the rise in heat of a substrate can be controlled like predetermined.

[0043] The influence of the temperature on the substrate of the T/S distance in the case of forming the thin film of aluminum is illustrated in the graph of drawing 3. For example, if T/S distance shall be 40 mm and 1500V intensity impression is carried out by DC power supply (16), the temperature of a substrate (12) will rise at about 70 \*\*, and it will be heated by still higher temperature if it shortens more. Therefore, in the process of forming a metal thin film, it becomes possible to heat-treat this invention. In another mode, it is also possible to include a heating method, for example, an electric heater, in the substrate holder (11) of a sputtering system, or to heat a substrate like predetermined with a lamp.

[0044] Adhesives are annularly supplied by rotating the substrates d1 and d2, holding one pair of substrates d1 and d2, inserting the tip nozzle of the adhesives feeder G in a gap, and breathing out the adhesives g so that a metal thin film may separate a gap and may counter after above-mentioned heat treatment. If the adhesives which narrow the gap of the substrate and are breathed out at this time are arranged where an up-and-down substrate is contacted, the application unevenness of adhesives can be substantially prevented from air bubbles permeating between substrates by the following laminating process, or arising.

[0045] In a laminating process, the layered product which the adhesives layer by which it is placed between gaps was thinly extended on the whole between substrates, and substrates stuck is obtained by narrowing these gaps further, rotating the substrates d1 and d2. Finally, it irradiates with ultraviolet ray lamp L to ultraviolet rays from one side of a layered product, adhesives are stiffened, lamination is completed, and optical disc D of this invention is obtained.

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## DESCRIPTION OF DRAWINGS

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[Brief Description of the Drawings]

[Drawing 1]It is a flow plan which shows the manufacturing method of the optical disc of this invention typically.

[Drawing 2]It is a typical sectional view of the sputtering system which can be used for heat treatment of the method of this invention.

[Drawing 3]It is a graph which shows the relation of the substrate temperature and T/S distance in a sputtering system.

[Drawing 4]It is a graph which shows the relation of change between the camber angle after pasting of a substrate, and the camber angle by an environmental test.

[Drawing 5]It is a mimetic diagram of the integrated production line of a bonding type optical disc based on the method of this invention.

[Drawing 6]It is a flow plan which shows the manufacturing method of the conventional optical disc typically.

[Description of Notations]

10 [ -- A target, 16 / -- DC power supply, 20 / -- A making machine, 30 / -- A thermal treatment equipment, 40 / -- A sputtering system, 50 / -- Laminating apparatus. ] -- Sputtering chambers, 11 -- A substrate holder, 12 -- A base, 14

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[Translation done.]

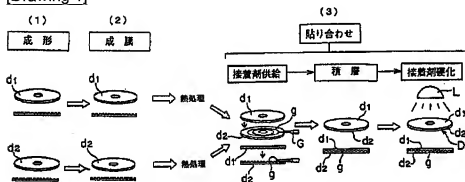
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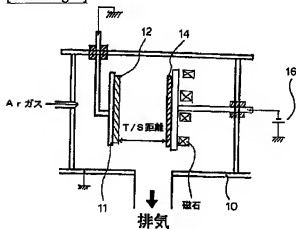
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## DRAWINGS

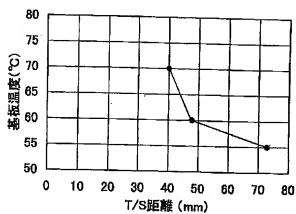
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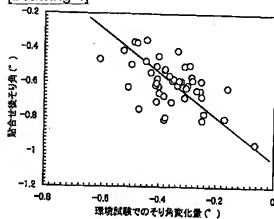
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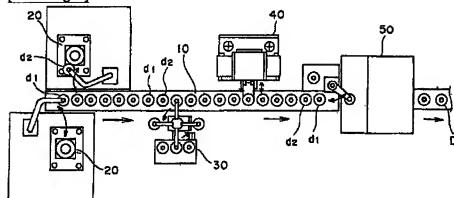
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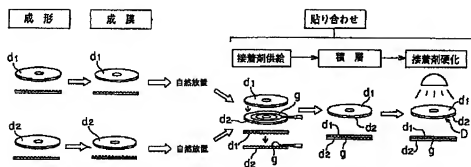
[Drawing 4]



[Drawing 5]



[Drawing 6]



[Translation done.]